

This listing of claims will replace all prior versions, and listings, of claims in the application:

**Listing of Claims:**

1. (Canceled)
2. (Previously presented) A light emitting device, comprising:  
a radiation source;  
a luminescent material; and  
a radiation scattering material located between the radiation source and the luminescent material;  
wherein:  
the radiation scattering material comprises radiation scattering particles located separately from the luminescent material;  
a mean diameter of the radiation scattering particles is between  $\lambda/3$  and  $\lambda/2$ , where  $\lambda$  is a first peak emission wavelength of the radiation source;  
the radiation source comprises a light emitting diode or a laser diode emitting radiation having the first peak emission wavelength; and  
the luminescent material comprises a phosphor which emits radiation having a second peak wavelength in response to incident radiation source radiation.
3. (Previously Presented) The device of claim 2, wherein:  
the radiation source comprises a blue or ultraviolet light emitting diode or laser diode;  
and  
the luminescent material comprises a phosphor layer or a dispersion of phosphor in a transmissive encapsulating material.
4. (Original) The device of claim 2, wherein:  
the radiation source comprises a blue light emitting diode; and  
the luminescent material comprises a yellow light emitting phosphor layer or a dispersion of a yellow light emitting phosphor in a polymer material.

5. (Original) The device of claim 4, wherein the light emitting diode comprises a blue emitting InGaN light emitting diode and the luminescent material comprises a dispersion of an epoxy or silicone and a YAG:Ce<sup>3+</sup> phosphor.

6. (Original) The device of claim 3, wherein the radiation source comprises an ultraviolet light emitting diode and the luminescent material emits white light in response to the ultraviolet radiation emitted by the light emitting diode.

7. (Previously Presented) A light emitting device, comprising:  
a radiation source;  
a luminescent material; and  
a radiation scattering material located between the radiation source and the luminescent material;  
wherein:  
the radiation scattering material comprises radiation scattering particles located separately from the luminescent material;  
the radiation source comprises a light emitting diode or a laser diode emitting radiation having a first peak emission wavelength; and  
the luminescent material comprises an organic dye which emits radiation having a second peak wavelength in response to incident radiation source radiation.

8. (Original) The device of claim 2, wherein the radiation scattering material comprises a layer of packed radiation scattering particles.

9. (Original) The device of claim 2, wherein the radiation scattering material comprises radiation scattering particles in a carrier medium comprising a transmissive body.

10. (Original) The device of claim 9, wherein:  
the radiation scattering particles comprise particles selected from a group consisting of TiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>; and

the carrier medium is selected from glass, silicone and plastic material.

11. (Original) The device of claim 9, wherein:  
the radiation scattering particles comprise 140 to 240 nm particles selected from a group consisting of  $\text{TiO}_2$ ,  $\text{BaTiO}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{CaCO}_3$ ,  $\text{BaSO}_4$ , and diamond; and  
the carrier medium is selected from glass, epoxy, silicone and urea resin.

12. (Original) The device of claim 9, further comprising:  
a package supporting the radiation source comprising a light emitting diode; and  
wherein the radiation scattering particles in the carrier medium are located above the light emitting diode and the luminescent material is located above the radiation scattering particles in the carrier medium.

13. (Original) The device of claim 12, wherein the radiation scattering particles in a carrier medium comprise at least one of the following:

- a) at least one light or UV radiation scattering particle layer in a glass passivation layer directly over the light emitting diode; and
- b) light or UV radiation scattering particles in a silicone layer over the light emitting diode or over and on sides of the light emitting diode.

14. (Previously Presented) A light emitting device, comprising:  
a radiation source;  
a luminescent material;  
a radiation scattering material located between the radiation source and the luminescent material; and  
a package supporting the radiation source;  
wherein:  
the radiation scattering material comprises radiation scattering particles located separately from the luminescent material;  
the radiation source comprises a light emitting diode emitting radiation having a first peak emission wavelength;

the luminescent material comprises a phosphor which emits radiation having a second peak wavelength in response to incident radiation source radiation;

the radiation scattering material comprises the radiation scattering particles located in a carrier medium comprising a transmissive body and a light or UV radiation scattering particle layer located on sidewalls of a reflector cup portion of the package containing the light emitting diode; and

the radiation scattering particles in the carrier medium are located above the light emitting diode and the luminescent material is located above the radiation scattering particles in the carrier medium.

15. (Previously Presented) The device of claim 14, wherein the radiation scattering material comprises all three of:

a) at least one light or UV radiation scattering particle layer in a glass passivation layer directly over the light emitting diode;

b) light or UV radiation scattering particles in a silicone layer over the light emitting diode or over and on sides of the light emitting diode; and

c) the light or UV radiation scattering particle layer on the sidewalls of the reflector cup portion of the package containing the light emitting diode.

16. (Previously Presented) A light emitting device, comprising:

a radiation source;

a luminescent material; and

a radiation scattering material located between the radiation source and the luminescent material;

wherein:

the radiation scattering material comprises radiation scattering particles located separately from the luminescent material;

the radiation source comprises a light emitting diode or a laser diode emitting radiation having a first peak emission wavelength;

the luminescent material comprises a phosphor which emits radiation having a second peak wavelength in response to incident radiation source radiation; and

the radiation scattering particles are located in a carrier medium comprising a transmissive body and the radiation scattering particles comprise at least two layers of TiO<sub>2</sub> particles in about a 1 micron to about a 2 micron thick silica layer arranged to achieve photonic crystal effects.

17. (Canceled)

18. (Previously Presented) The device of claim 2, wherein the radiation scattering particles scatter at least 50% more radiation source radiation than luminescent material radiation.

19. (Previously Presented) The device of claim 2, wherein the radiation scattering material does not luminesce and the luminescent material does not substantially scatter light or UV radiation.

20. (Previously Presented) The device of claim 19, wherein the luminescent material comprises a nanocrystalline phosphor.

21. (Currently Amended) A white light emitting device, comprising:  
a package containing a reflector cup;  
a light emitting diode in the reflector cup;  
radiation scattering particles in a packed layer or in a carrier medium over the light emitting diode; and

a phosphor or an organic dye which emits radiation having a second peak wavelength in response to incident light emitting diode radiation having a first peak wavelength, such that the device output appears white to an observer;

wherein the phosphor or organic dye is located over and separately from the radiation scattering particles located in the packed layer or in the carrier medium and the phosphor or organic dye comprises a layer which does not contain radiation scattering particles.

22. (Currently Amended) The device of claim 21, wherein:

the light emitting diode comprises a blue or an ultraviolet light emitting diode;  
the radiation scattering particles comprise light or UV radiation scattering particles in a carrier medium; and  
the ~~luminescent material~~ phosphor or the organic dye comprises a yellow or white light emitting phosphor layer or a dispersion of a phosphor in an epoxy or silicone.

23. (Currently Amended) The device of claim 22, wherein:  
the light emitting diode comprises a light emitting diode having an emission wavelength of 365 to 420 nm; and  
the ~~luminescent material~~ phosphor or the organic dye comprises:  
i) a white light emitting phosphor layer comprising one or more phosphors; or  
ii) a dispersion of at least one phosphor and an epoxy or silicone.

24. (Currently Amended) The device of claim 22, wherein the light emitting diode comprises a blue emitting InGaN light emitting diode and the ~~luminescent material~~ phosphor or the organic dye comprises a dispersion of an epoxy or silicone and a YAG:Ce<sup>3+</sup> phosphor.

25. (Currently Amended) ~~The device of claim 22, wherein:~~  
A white light emitting device, comprising:  
a package containing a reflector cup;  
a light emitting diode in the reflector cup;  
radiation scattering particles in a carrier medium over the light emitting diode; and  
a phosphor which emits radiation having a second peak wavelength in response to incident light emitting diode radiation having a first peak wavelength, such that the device output appears white to an observer;  
wherein:  
the phosphor is located over and separately from the radiation scattering particles located in the carrier medium;  
the light emitting diode comprises a blue or an ultraviolet light emitting diode;

the radiation scattering particles comprise light or UV radiation scattering particles in the carrier medium;

the phosphor comprises a yellow or white light emitting phosphor layer or a dispersion of a phosphor in an epoxy or silicone;

the radiation scattering particles are selected from a group consisting of  $\text{TiO}_2$ ,  $\text{BaTiO}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{CaCO}_3$ ,  $\text{BaSO}_4$  and diamond particles having a mean diameter of 50 to 500 nm; and

the carrier medium is selected from glass, epoxy, silicone and urea resin.

26. (Original) The device of claim 25, wherein the light scattering particles in a carrier medium comprise at least one of the following:

a) light or UV radiation scattering particles in a glass passivation layer over the light emitting diode; and

b) light or UV radiation scattering particles in a silicone layer over the light emitting diode or over and on sides of the light emitting diode.

27. (Original) The device of claim 26, wherein the light scattering particles in a carrier medium comprise both a), b) and

c) a light or UV radiation scattering layer on sidewalls of the reflector cup.

28. (Original) The device of claim 27, wherein the particles in the glass passivation layer comprise 120 to 200 nm  $\text{TiO}_2$  particles in a silica glass layer.

29. (Original) The device of claim 27, wherein the particles in the silicone layer comprise a silicone layer containing 5-10% of 120 to 200 nm amorphous silica particles in contact with the top and the sides of the light emitting diode.

30. (Original) The device of claim 27, wherein the light or UV radiation scattering layer on the sidewalls of the reflector cup comprises a  $\text{MgF}_2$  layer or a polymer layer.

31. (Currently Amended) ~~The device of claim 22, wherein:~~

A white light emitting device, comprising:

a package containing a reflector cup;

a light emitting diode in the reflector cup;

radiation scattering particles in a carrier medium over the light emitting diode; and

a phosphor which emits radiation having a second peak wavelength in response to incident light emitting diode radiation having a first peak wavelength, such that the device output appears white to an observer;

wherein:

the phosphor is located over and separately from the radiation scattering particles located in the carrier medium;

the light emitting diode comprises a blue or an ultraviolet light emitting diode;

the radiation scattering particles comprise light or UV radiation scattering particles in the carrier medium;

the phosphor comprises a yellow or white light emitting phosphor layer or a dispersion of a phosphor in an epoxy or silicone;

a mean diameter of the radiation scattering particles is between  $\lambda/3$  and  $\lambda/2$ , where  $\lambda$  is the peak emission wavelength of the radiation source; and

the radiation scattering particles scatter at least 50% more radiation source radiation than luminescent material radiation.

32. (Previously Presented) A method of generating white light from a light emitting device, comprising a light emitting diode, a phosphor luminescent material and a radiation scattering material located between the light emitting diode and the luminescent material, wherein the radiation scattering material comprises radiation scattering particles located separately from the luminescent material, and a mean diameter of the radiation scattering particles is between  $\lambda/3$  and  $\lambda/2$ , where  $\lambda$  is a first peak emission wavelength of the radiation source;

the method comprising:

supplying power to the light emitting diode;



generating a directional radiation comprising blue light or ultraviolet radiation having the first peak emission wavelength;

passing the directional radiation through the radiation scattering material to diffuse the directional radiation in a plurality of directions;

providing the diffuse radiation comprising blue light or ultraviolet radiation onto the luminescent material; and

generating white light by emitting radiation having a second peak wavelength from the luminescent material.

33. (Currently Amended) The method of claim 32, wherein:

the first step of generating comprises generating blue light;

the step of passing comprises passing the blue light through light scattering particles;

the step of providing comprises providing the diffuse blue light onto the luminescent material which comprises a yellow light emitting phosphor; and

the second step of generating comprises providing a mix of the yellow light from the phosphor and the blue light from the light emitting diode that is transmitted through the phosphor.

34. (Currently Amended) The method of claim 32, wherein:

the first step of generating comprises generating radiation having a wavelength between 365 and 420 nm;

the step of passing comprises passing the radiation through radiation scattering particles;

the step of providing comprises providing the diffuse radiation onto the luminescent material which comprises at least one white light emitting phosphor; and

the second step of generating comprises generating white light from the at least one phosphor.

35. (Original) The method of claim 34, wherein the radiation comprises ultraviolet radiation.

36. (Original) A light emitting device, comprising:  
a radiation source;  
a luminescent material layer which does not substantially exhibit Mie scattering; and  
a radiation scattering phosphor layer, which exhibits Mie scattering of the radiation source radiation, located between the radiation source and the luminescent material.

37. (Currently Amended) The device of claim 36, wherein:  
the radiation source comprises a blue light emitting diode;  
the luminescent material layer comprises a discrete yellow light emitting phosphor layer having a first mean particle diameter; and  
the radiation scattering phosphor layer comprises a discrete yellow emitting phosphor layer having a second mean particle diameter smaller than the first mean particle diameter.

38. (Original) The device of claim 37, wherein the luminescent material comprises  $\text{YAG:Ce}^{3+}$  having a mean particle diameter between 1 to 10 microns and the radiation scattering phosphor comprises  $\text{YAG:Ce}^{3+}$  having a mean particle diameter between 120 and 200 nm.

39. (Currently Amended) The light emitting device of claim 21, wherein the luminescent material is located separately from the radiation scattering particles.

40. (Cancelled).

41. (Previously Presented) The light emitting device of claim 21, wherein the radiation scattering particles in the packed layer or in the carrier medium are located separately from the phosphor or organic dye.

42. (Previously Presented) The light emitting device of claim 36, wherein the radiation source comprises a light emitting diode.

## REMARKS

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and in view of the reasons which follow. This amendment adds, changes and/or deletes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, are presented, with an appropriate defined status identifier. After amending the claims as set forth above, claims 2-16, 18-39 and 41-42 are now pending in this application.

Applicants appreciate the indication that claims 2-16, 18-20, 25-38, 40 and 42 are allowed and that claims 25-31 would be allowed if rewritten in independent form. In response, claims 25 and 31 have been rewritten in independent form.<sup>1</sup>

Figure 6 is objected to. In response, Figure 6 was amended to include a "Prior Art" label in the Amendment After Final Rejection filed June 20, 2003. The USPTO approved these formal drawings in the Advisory Action mailed July 25, 2003.

Claims 33, 34, 37 and 40 are objected to. In response, claims 33, 34, 37 were amended and claim 40 was cancelled without prejudice or disclaimer, according to the examiner's helpful suggestion.

Claim 39 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 39 has been amended to depend from claim 2 to overcome the rejection.

Claims 21-24 and 41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hohn et al, U.S. Patent 6,066,861 ("Hohn"). This rejection is respectfully traversed.

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<sup>1</sup> Claims 25 and 31 depend from claim 22, which depends from claim 21. Claim 21 recites a phosphor or an organic dye in the alternative, and also recites radiation scattering particles in a packed layer or in a carrier medium in the alternative. Claim 22 recites a phosphor and radiation scattering particles in a carrier medium. The limitations of both claims 21 and 22 were incorporated into each of the claims 25 and 31. Thus, the organic dye and the radiation scattering particles in a packed layer are not mentioned in claims 25 and 31 to avoid confusion.

Page 7 of the Office Action notes that Hohn teaches to place the radiation scattering particles into both the envelope 15 and into the casting composition 5 containing the phosphor. Thus, since the envelope 15 and the composition 5 are separate items, the Office Action concludes that the phosphor in the casting composition 5 is located separately from the scattering particles in the envelope 15, and that this meets the limitations of claim 21.

Claim 21 has been amended to clarify that "the phosphor or organic dye comprises a layer which does not contain radiation scattering particles." Support for this amendment may be found, for example, on page 7, lines 4-6 of the specification and in Figure 5. This claim limitation excludes the casting composition 5 of Hohn which contains mixed phosphor and radiation scattering particles. Thus, Hohn does not teach or suggest a phosphor or organic dye which comprises a layer which does not contain radiation scattering particles in combination with radiation scattering particles located under this phosphor or dye layer, as recited in claim 21. Applicants respectfully request a withdrawal of the § 103(a) rejection.

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested. The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

Respectfully submitted,

Date

8/19/03

By



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The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

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